Assessing Polarimetric SAR Interferometry coherence region parameters over a permafrost landscape

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Abstract

Rising temperatures in the Arctic are leading to recent changes in permafrost regions. The monitoring of permafrost state and dynamics benefits from the large-scale capabilities of airborne and spaceborne remote sensing as well as the opportunity to image regions that are difficult to access. In this regard, the German Aerospace Center (DLR) conducted an experimental airborne SAR campaign aiming at characterizing SAR responses over permafrost landscapes and assessing to which extent parameters of interest, such as soil moisture and soil layer properties, can be estimated in such regions [1]. The campaign comprises two data sets acquired in the Canadian Arctic in August 2018, when the upper layer of the soil is thawed, and in March 2019, when the ground is entirely frozen. Smaller (X- and C-band) and larger (L-band) wavelengths were used.

This study focuses on a particular test site encompassing the Trail Valley Creek catchment (Northwest Territories), which is a well-studied area of continuous permafrost covered by tundra vegetation [2]. Previous polarimetric analysis shows an overall decrease in backscattering power of several dB from summer to winter and a relative increase of the surface contribution (entropy/alpha analysis) [3]. Simultaneously, landscape features remain clearly recognizable at all wavelengths in winter. As permafrost parameters (vegetation, soil moisture, soil type, winter snow depth) are suspected to be related with another [2], unambiguous interpretation of the signal is challenging. Adding another dimension (interferometry) related to phase center height and therefore signal penetration depth is a step towards better interpretation of the signal. As several baselines were flown over Trail Valley Creek test site and fully polarimetric data was acquired, polarimetric SAR interferometry observables can be retrieved.

A particular parameter of interest is the coherence region, namely the set of coherences that can be obtained from all possible pairs of polarimetric acquisitions at a given baseline. Pol-InSAR coherence regions are characterized by their shape and extent in the complex plane. In particular, their extent in amplitude and phase in the complex plane are of interest, as they can be related to the vertical distribution of scatterers within a given resolution cell. In summer, overall small vegetation (below 1m) covers the soil, and little penetration into the ground is expected as the upper layer of the soil is thawed. In winter, the soil is entirely frozen, covered by snow, and the vegetation is partially frozen. Larger penetration into the frozen soil is expected at larger wavelengths. These effects could influence the coherence region features.

An analysis and a comparison of the Pol-InSAR coherence region parameters for the winter and summer datasets over the Trail Valley Creek catchment will be presented. Several frequencies will be considered and the influence of landcover will be assessed by discriminating between different vegetation types.

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